Mars Sample Return Lander Mission Concepts

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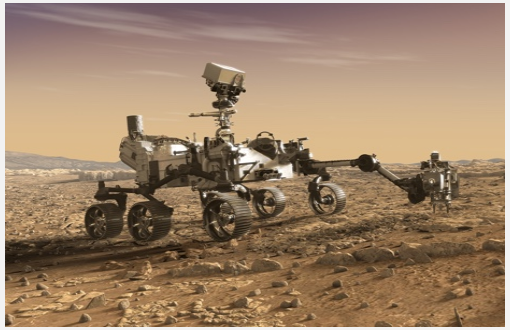
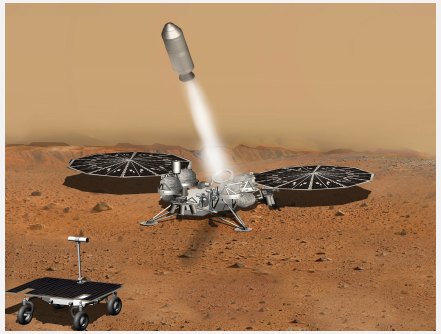
MSR Campaign Architecture Elements Under Study



Sample Caching Rover (Mars 2020)

- *Sample acquisition and caching*

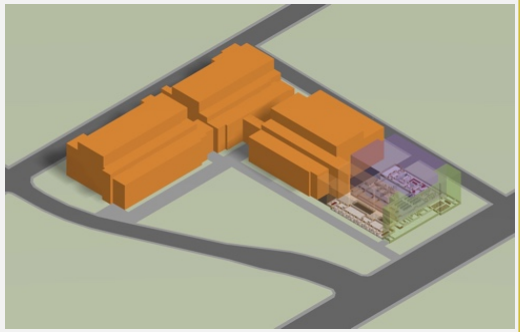


Sample Retrieval Lander

- *Fetch Rover*
- *Orbiting Sample container (OS)*
- *Mars Ascent Vehicle*

Earth Return Orbiter

- *Capture/Containment Module*
- *Earth Return Module*



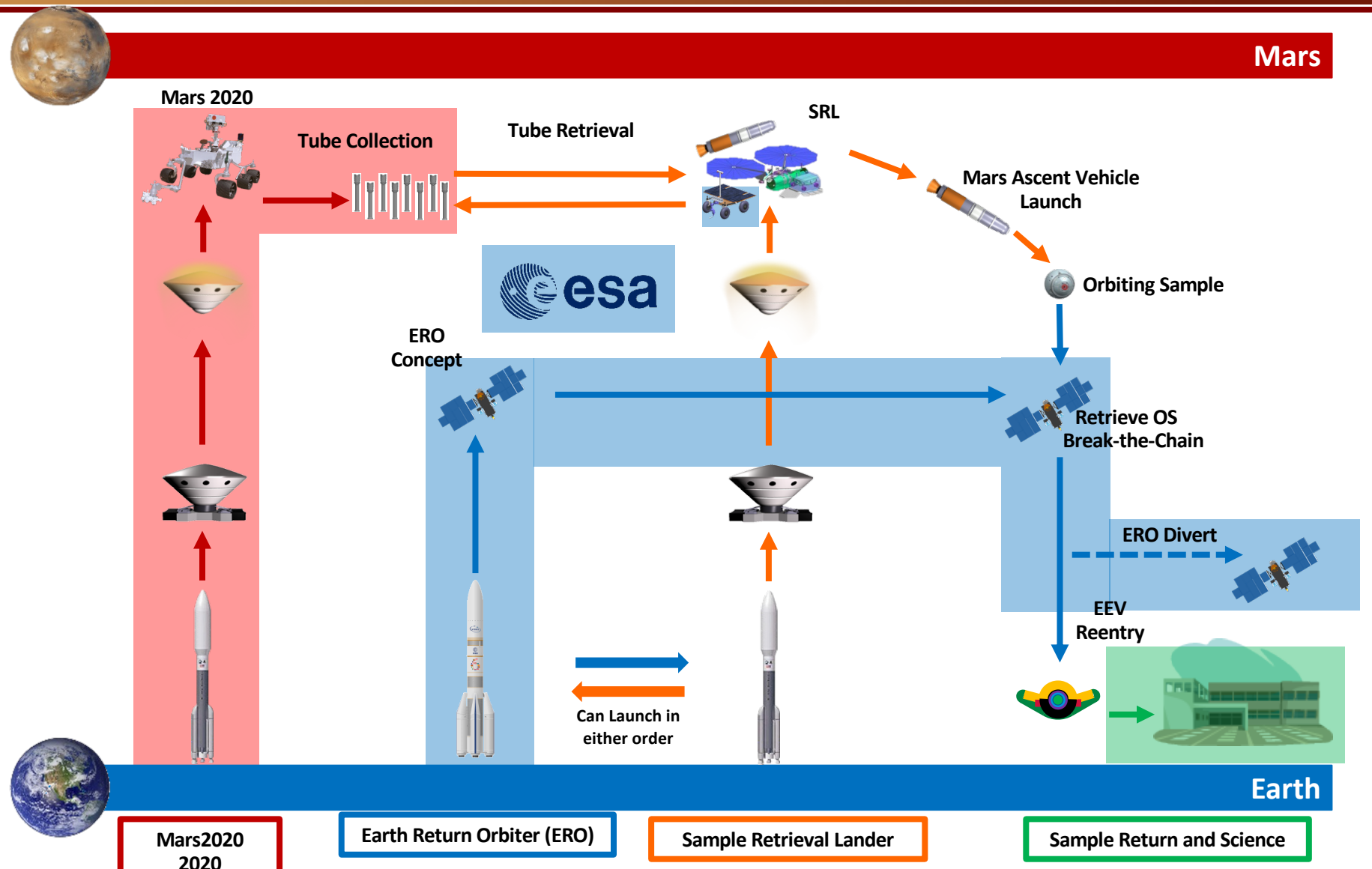
Mars Returned Sample Handling

- *Sample Receiving Facility*
- *Curation*
- *Sample science investigations*

Flight Elements

Ground Element

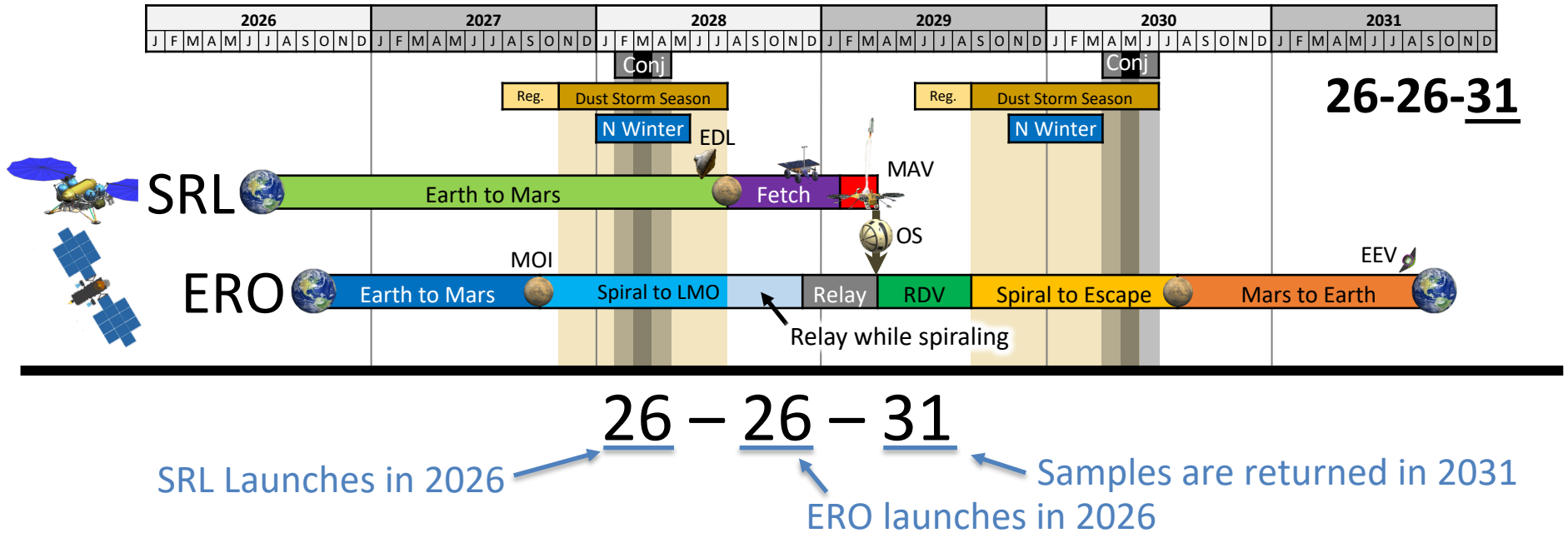
MSR Mission Scenario and Roles*



*Per NASA/ESA Joint Statement of Intent, 4/26/18

26-26-31 Campaign Timeline

*Timeline is illustrative, not exact



26 – 26 – 31

SRL Launches in 2026

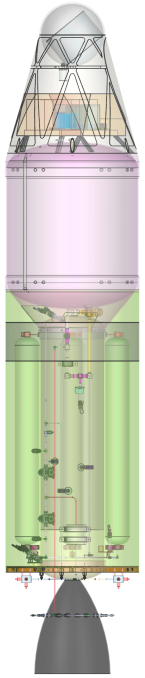
ERO launches in 2026

Samples are returned in 2031

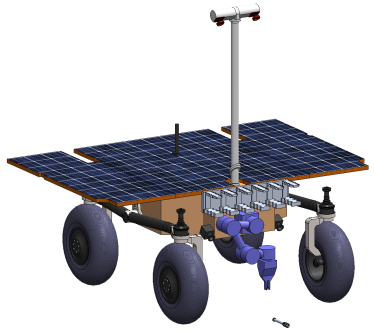
- SRL takes a Type III transfer to land in Northern spring, avoiding dust storm season and improving EDL atmosphere
- ERO takes a SEP-assisted ½ revolution transfer and takes ~14 months to spiral to low orbit from the elliptical post-MOI orbit. The last few months of spiraling include relay support for SRL surface mission
- SRL surface mission is around 8 months long, with 5 allocated to fetching
- Rendezvous, capture, and payload operations are around 5 months long
- Return transfer is entirely EP and takes around 2 years (including spiral)

Key MSR Technology Needs

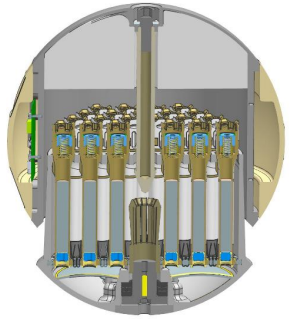
Sample Retrieval Lander



Mars Ascent Vehicle

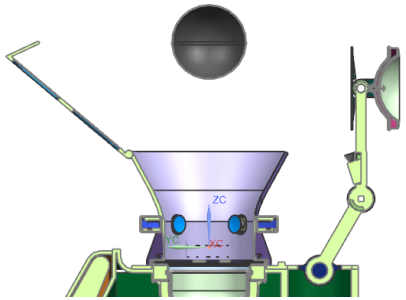


Sample Fetch Rover

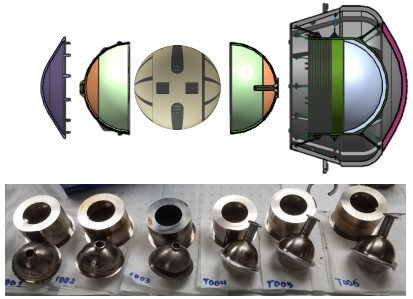


Orbiting Sample (OS) Container

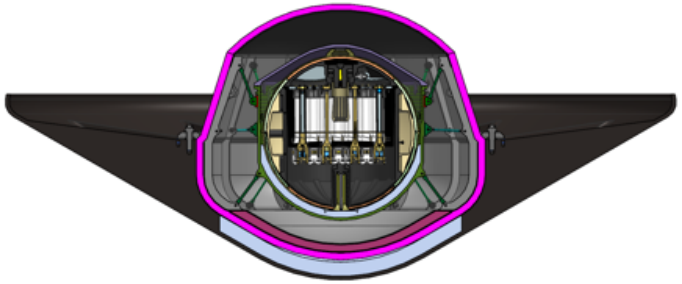
Earth Return Orbiter



Rendezvous and Capture

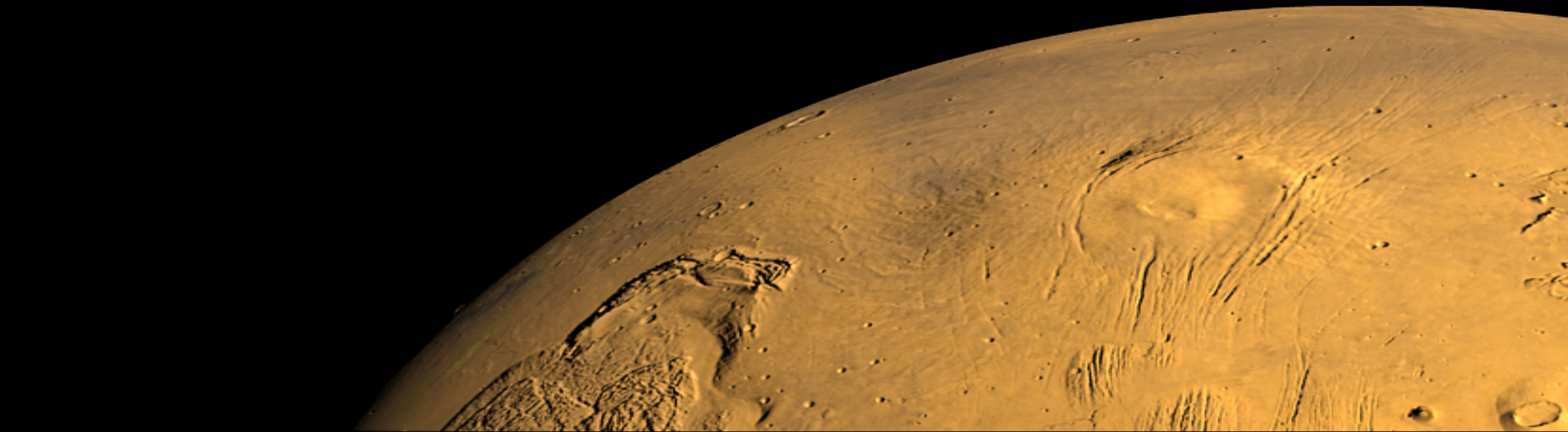


Containment Assurance



Earth Entry Vehicle

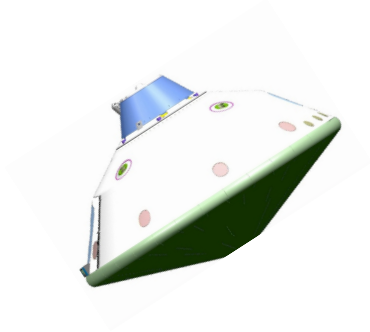
MSR Sample Retrieval Lander Major Element Concepts

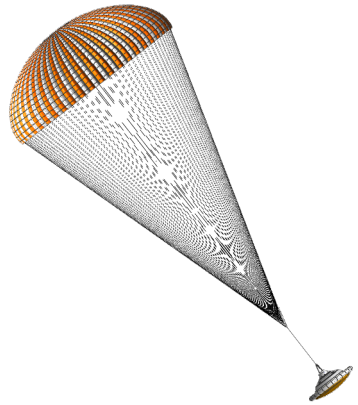


Lander Concept Options Mission Functions

Mission Functions:

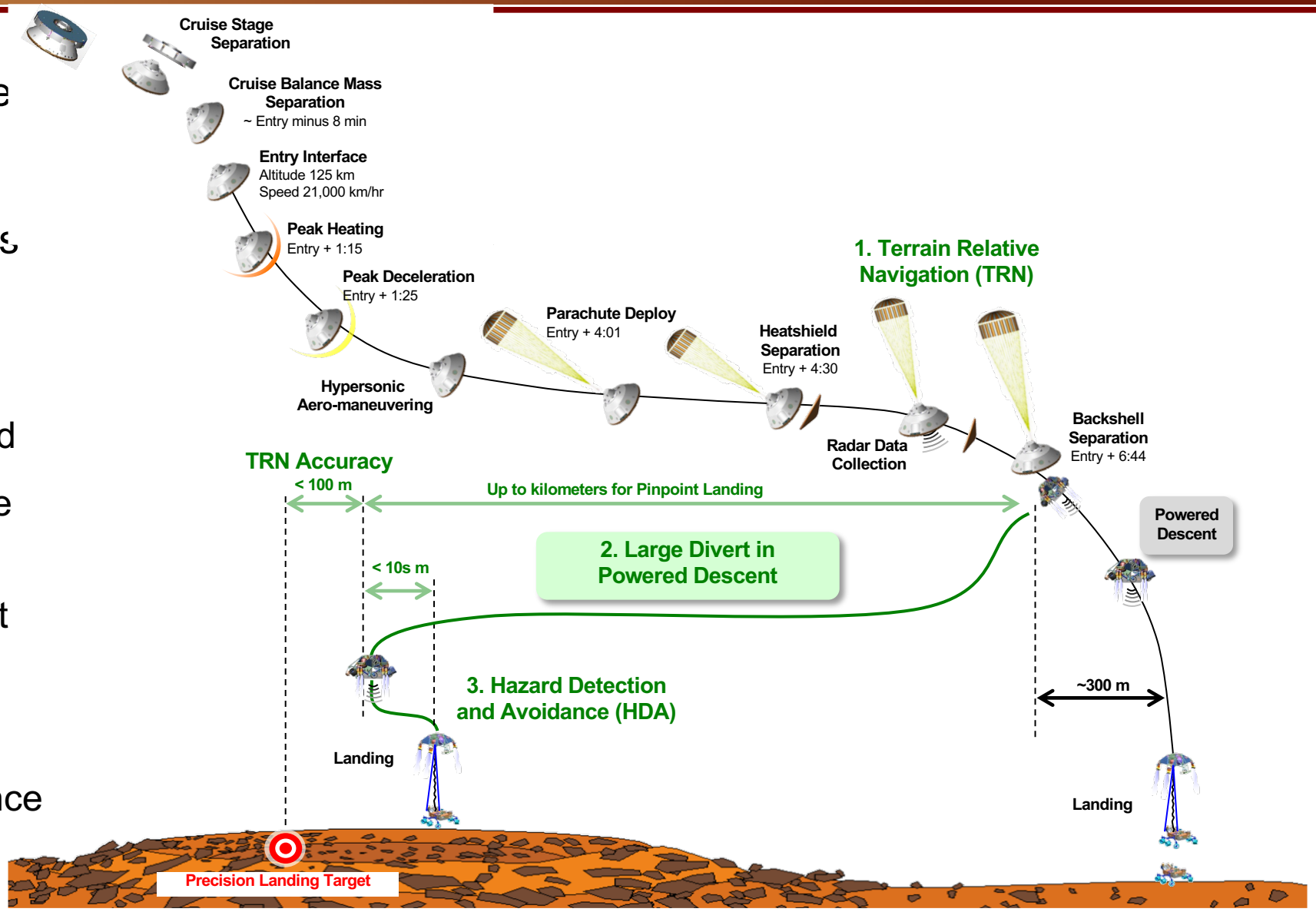
- Land on Mars using TRN
  - Entry, Descent and Landing (EDL) is common to M2020/MSL with specific possible augmentations
- Deploy the Sample Fetch Rover
- Maintain the lander and MAV within safe operating conditions
- Once the SFR returns with sample tubes, SRL must:
  - Transfer tubes to the Orbiting Sample (OS) container in the MAV Payload Assemby (MPA), using the Sample Transfer Arm (STA)
  - Close the MPA on the MAV
  - Prepare the MAV for launch (heat and erect)
  - Launch the MAV and eject the OS into low Mars orbit for retrieval by the Earth Return Orbiter (LMO)





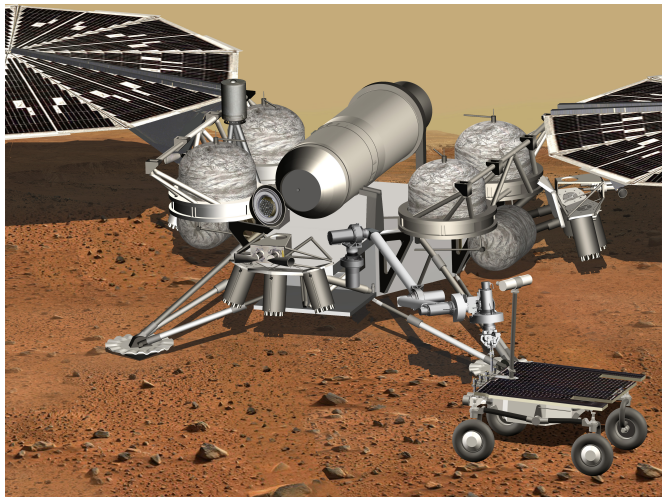
Potential EDL Augmentations

- Augmentations likely to be needed to accommodate larger landed mass and achieve mission objectives
- Augmentations being considered
  - 4.7m spherical heatshield
  - Higher Mach # parachute deploy
  - Start powered descent at higher altitude
  - Large divert
  - Terminal hazard avoidance

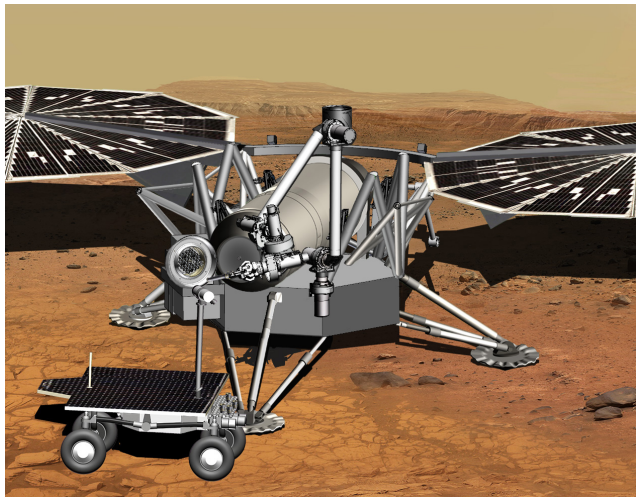


Lander Concept Options Key Studies

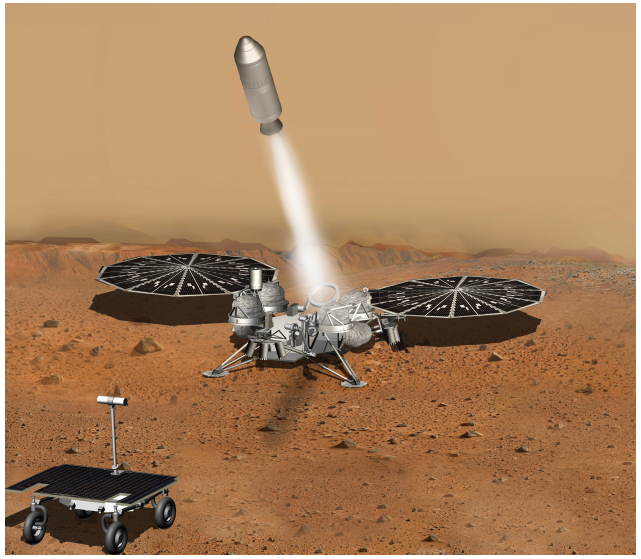
- Accommodation of MAV (400 kg) and Fetch Rover (120 kg) on lander in aeroshell, with volume and mass margins
- MAV propulsion technology, performance (including mass), and reliability
- OS and MAV Payload Assembly (MPA): Tube accommodation, OS protection and ejection into Mars orbit
- Planetary protection design and implementation strategies
- Surface plume interaction during landing

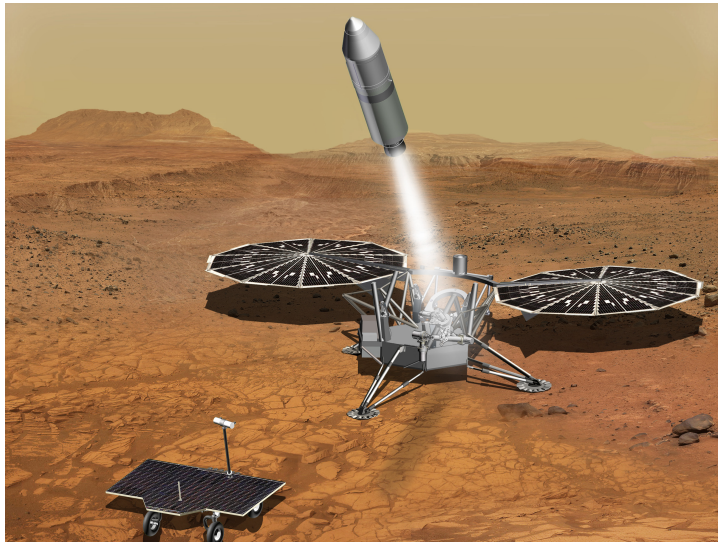


Propulsive Platform Lander



Skycrane Delivered Lander





Fetch Rover Concept

Mission Objectives

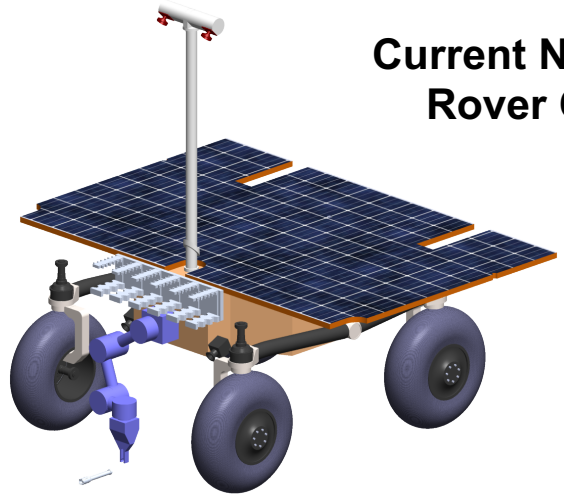
- Acquire sample tubes from the Mars surface
- Surface mission duration: 210 sols max
- Average traverse distance required: 150-250 m/sol

Key Specifications (based on NASA conceptual design)

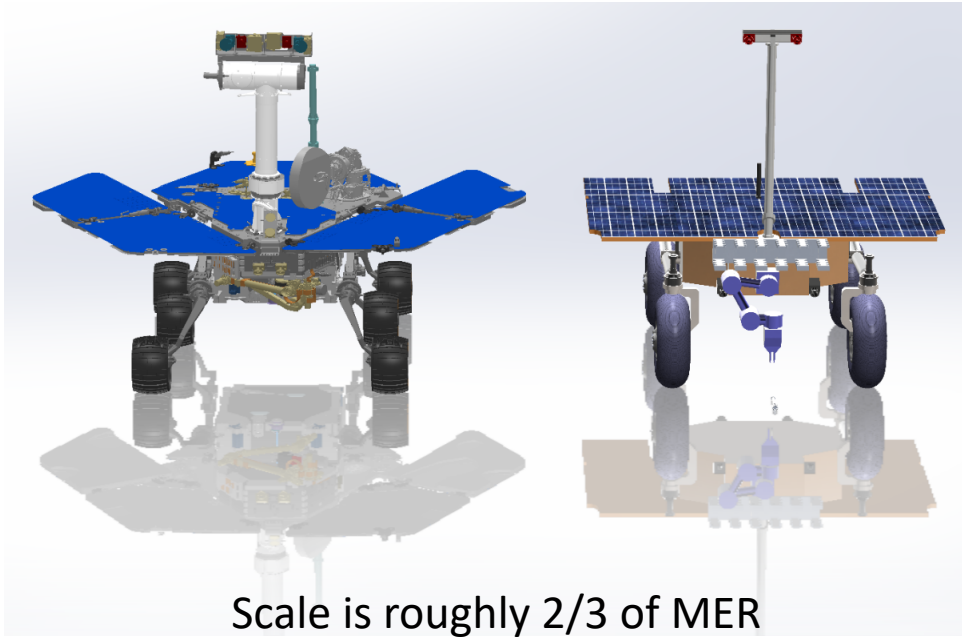
- Rover Mass: 120 kg (Not to Exceed)
- Stowed Volume: ~1 m^3
- Power Architecture: Solar powered, 1.5 m^2
- Navigation: Image processing to support autonomous driving
- Telecom: UHF relay to orbiters

M2020 Delivery

- M2020 as fetch was studied, concluded that that option is feasible and that most robust mission approach is to maintain both fetch rover and M2020



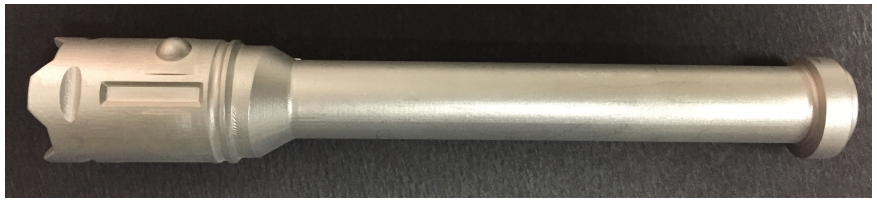
Current NASA Fetch Rover Concept



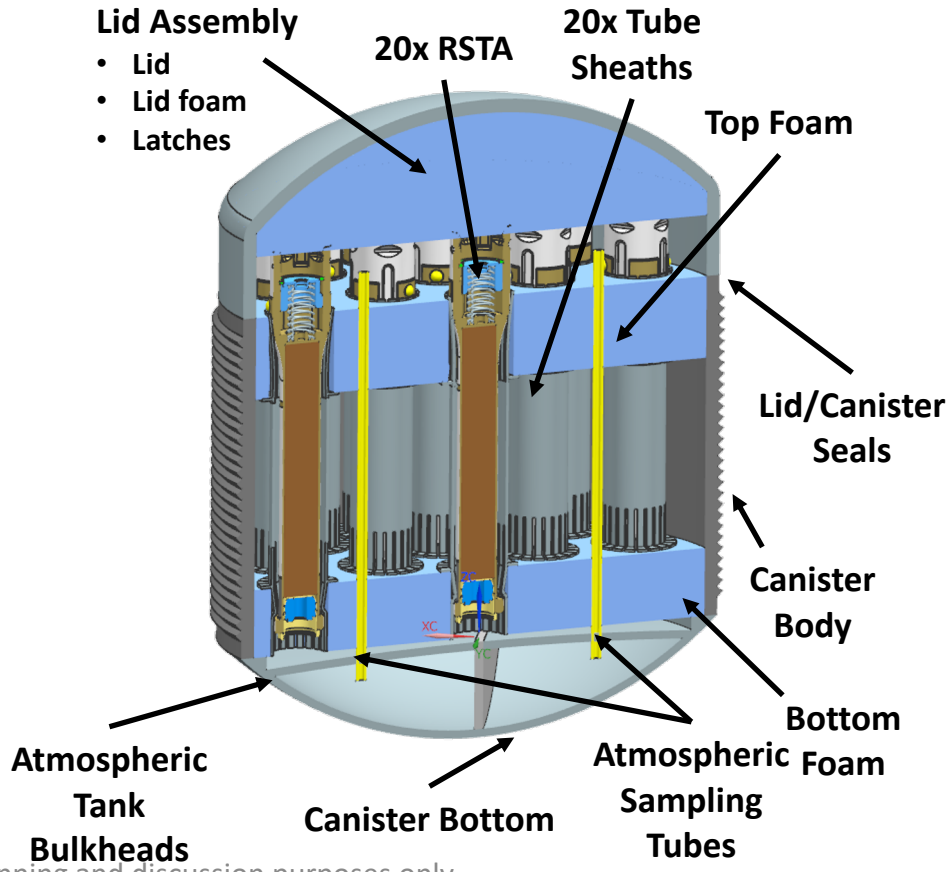
Scale is roughly 2/3 of MER

Sample Tube and Orbiting Sample (OS) Container Concept

- Return Sample Tube Assembly (RSTA) is designed to carry Mars material samples in pristine state from time of sample acquisition
- OS is designed to hold desired number of samples, currently 20-30
  - Tubes are inserted by Sample Transfer Arm on lander
  - OS then must be assembled & launched to orbit by MAV inside MAV Payload Assembly (MPA)
  - Hold samples securely through launch to Earth landing
- Maintain samples within environmental constraints
  - Sample temperature < +30 ºC
  - Keep magnetic fields < ½ mT at sample
- OS must accommodate rendezvous and tracking by visual wavelength cameras on orbiter
  - Sufficient albedo to be detected in Mars orbit



Return Sample Tube Assembly (RSTA)



Mars Ascent Vehicle (MAV) Concept

Mission Objectives

- Launch from all candidate M2020 landing sites
- Inject OS into >350 km altitude orbit, > 25 deg inclination

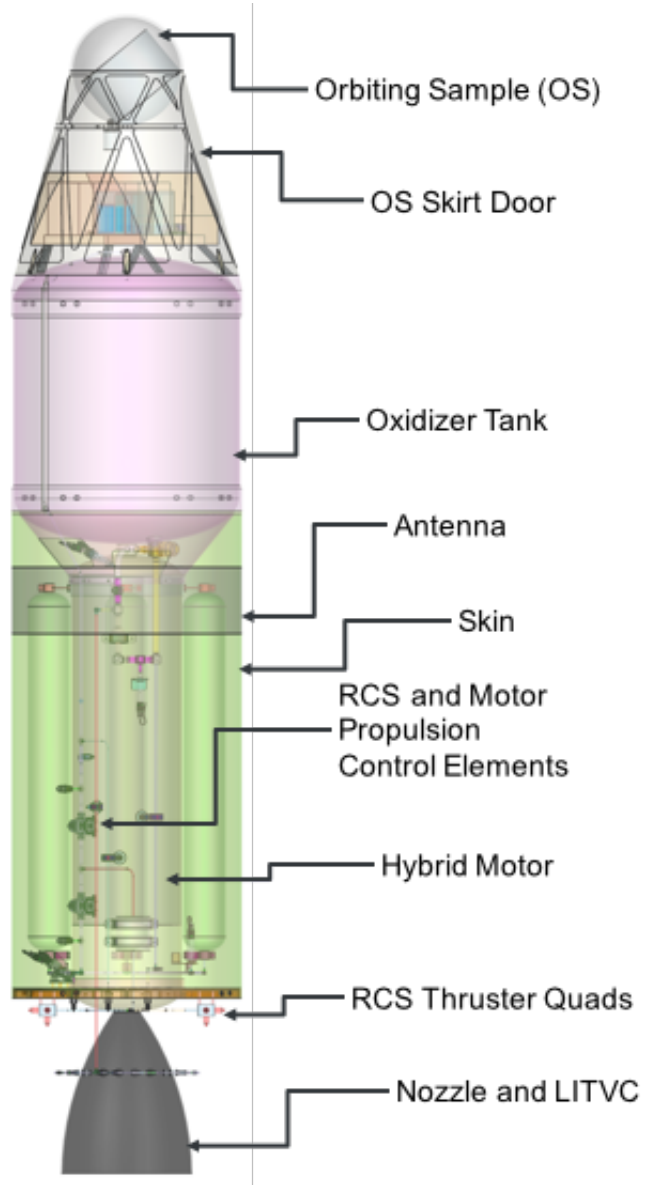
Technology Development Status

- Currently, two contractors are working to demonstrate performance of a single stage to orbit hybrid propulsion technology concept
  - Including ignition and stable combustion for the mission duration and a single restart
  - Both are achieving ignition with augmented combustion energy sources
- Developing demonstration of low temperature solid

Key Trade Studies in Work

- Overall vehicle design to meet Mars mass and volume constraints
- Thrust vector control
- Design for environments

Current hybrid concept
~400 kg Gross Liftoff Mass



MAV Hybrid Test

Trades Influenced by Backward Planetary Protection